Soil greenhouse gas pulses from a Tropical Dry Forest

SOFIA CALVO-RODRIGUEZ[1], RALF KIESE[2], SAULO CASTRO[1]

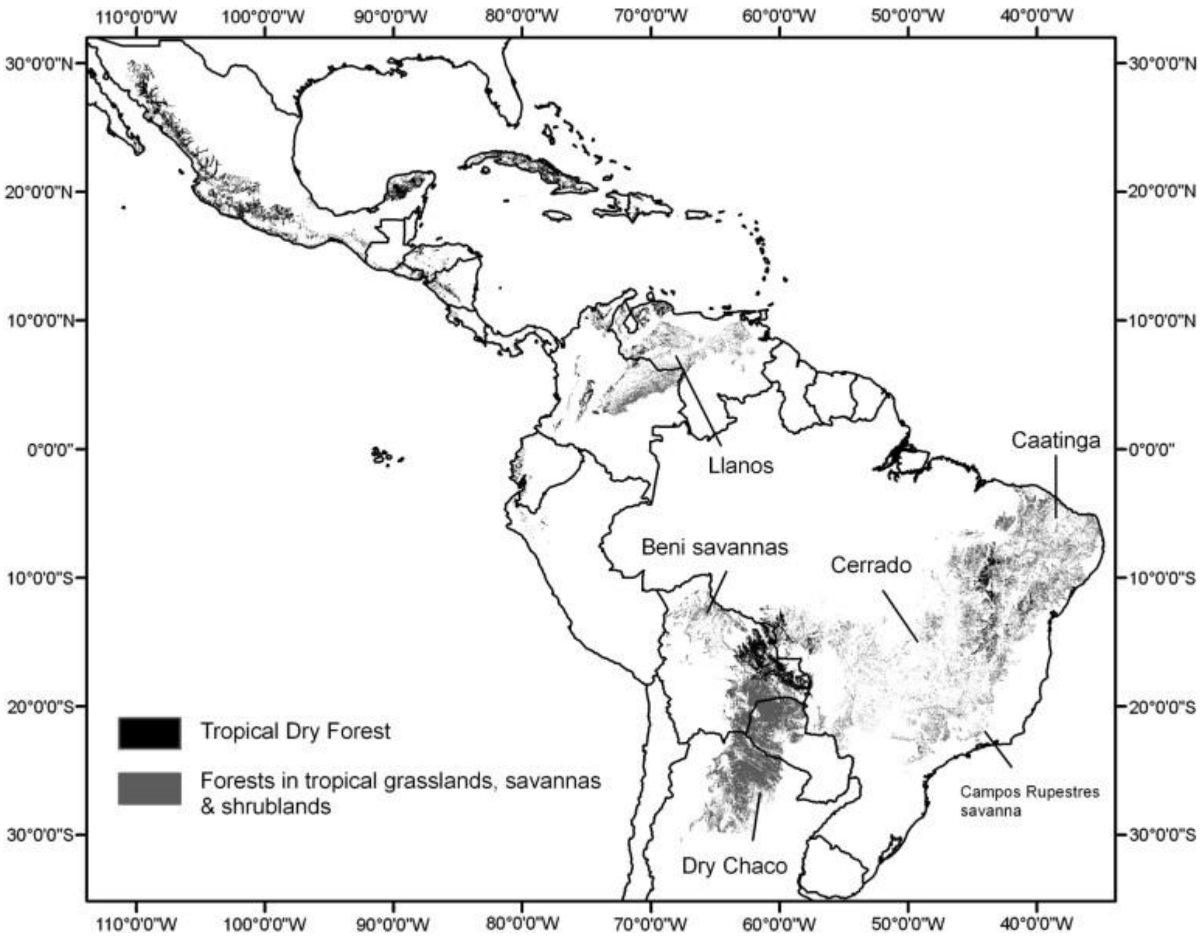
1. EARTH AND ATMOSPHERIC SCIENCES DEPARTMENT, UNIVERSITY OF ALBERTA, EDMONTON, ALBERTA, CANADA

2. INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH, ATMOSPHERIC ENVIRONMENTAL RESEARCH, KARLSRUHE INSTITUTE OF TECHNOLOGY, GARMISCH-PARTENKIRCHEN, GERMANY

calvorod@ualberta.ca

1. Introduction

- Tropical Dry Forest (TDF) represents 42% of all tropical forests. 54% of the total TDF global coverage is located in the Americas (Miles et al. 2006)
- Adapted to seasonal droughts
- Mean annual temperature is usually >25 °C
- Total annual precipitation ranges from 700 to 2000 mm
- At least 50% of plant species show seasonal deciduousness



C.A.Portillo-QuinteroG.A.Sánchez-Azofeifa (2010). Extent and conservation of tropical dry forests in the Americas. Biological Conservation

Motivation

→ Because of the extent of the dry season, TDF soils release large pulses of CO_2 upon rewetting, a phenomenon known as the 'Birch effect' (Birch 1958). These rewetting pulses constitute a substantial portion of annual soil CO_2 flux in TDF (Waring et al. 2016)

→ The 'Birch effect' has been observed also in TDF inter-annually at the ecosystem level through eddy covariance methods (Castro et al. 2017)

→ Studies evaluating seasonal variations of soil green house gases (GHG) from TDF and the contribution of N_2O and CH_4 to these pulses are currently scarce

2. Specific Objectives

1. Evaluate the seasonal variations and pulses of soil CO_2, N_2O and CH_4 fluxes in a Tropical Dry Forest with different land covers

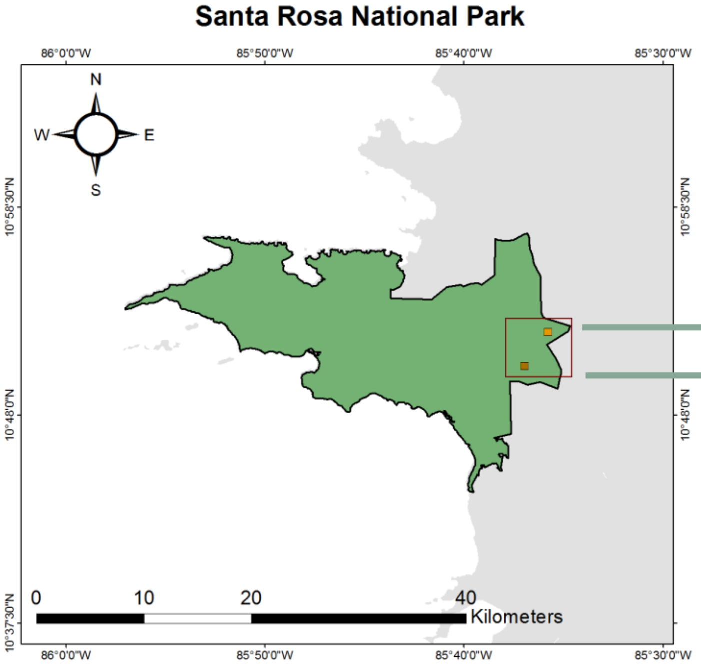
2. Quantify the seasonal and annual sink/source strength of GHG using manual and automatic chambers

3. Evaluate environmental factors controlling GHG exchanges in different forest successional stages

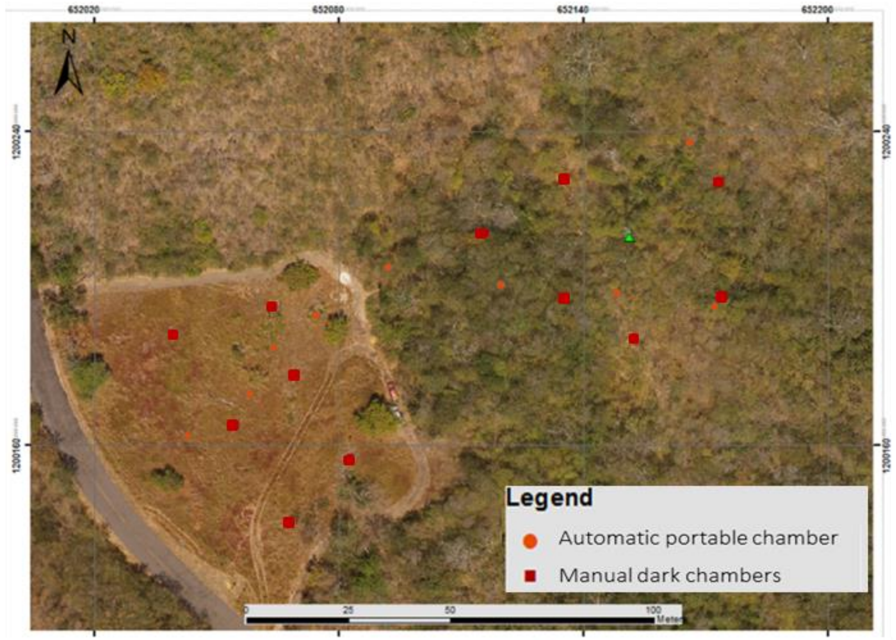
3. Equipment and materials:

- Manual static dark chambers (6 chambers per plot)
- Automatic Long-Term LI-COR chambers and portable LI-COR dark chamber
- Eddy covariance tower with meteorological station (Castro et al. 2017) and soil moisture sensors (EC5 Decagon Devices; WA, USA)

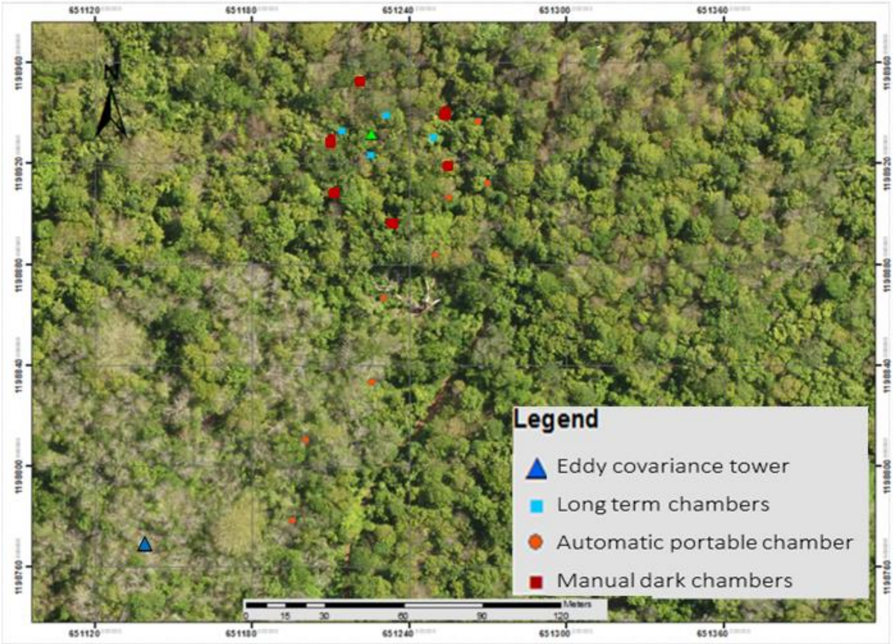
Study site SR-EMSS



Early stage and pasture



Late stage



Definition of successional stages

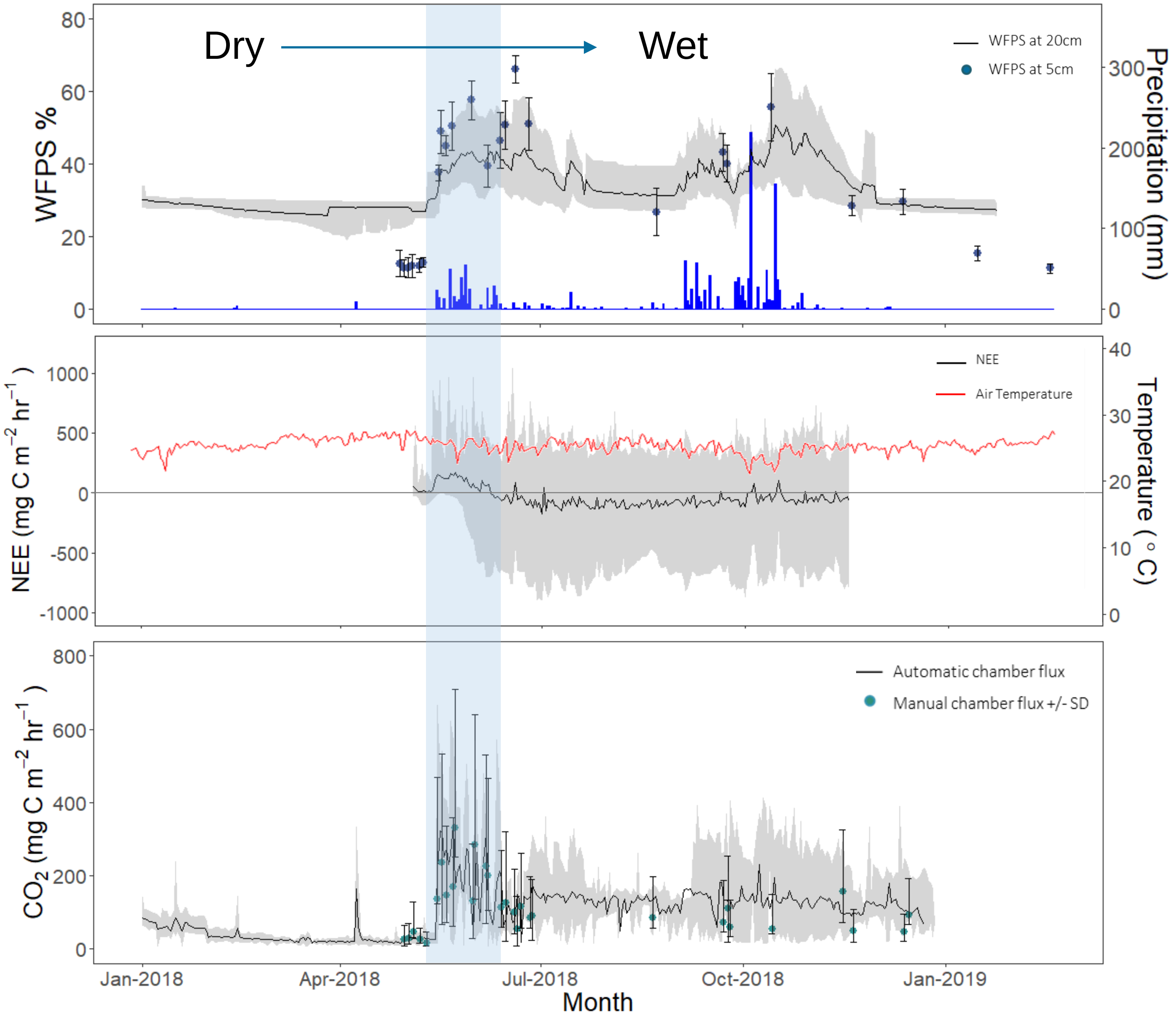
Pasture: Fire-breaks inside the park originally used as pastures for cattle

Early stage: Forest ~30 years old, originally used as pastures for cattle or for agricultural purposes

Late stage (mature forest): Forests above 50 years old that regenerate after logging activities and less intense fires

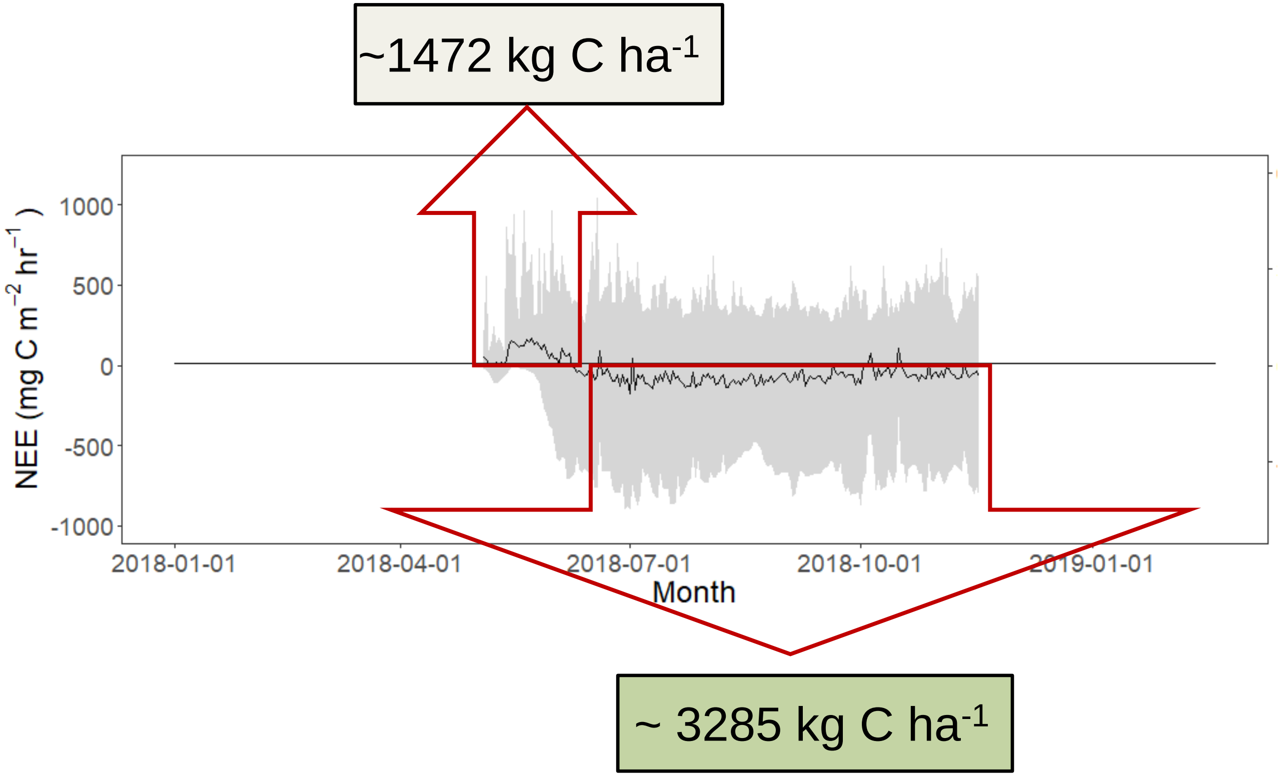
4. Results

In the transition month, large pulses of soil CO_2 emissions cause the NEE to become positive, turning the forest into a carbon source



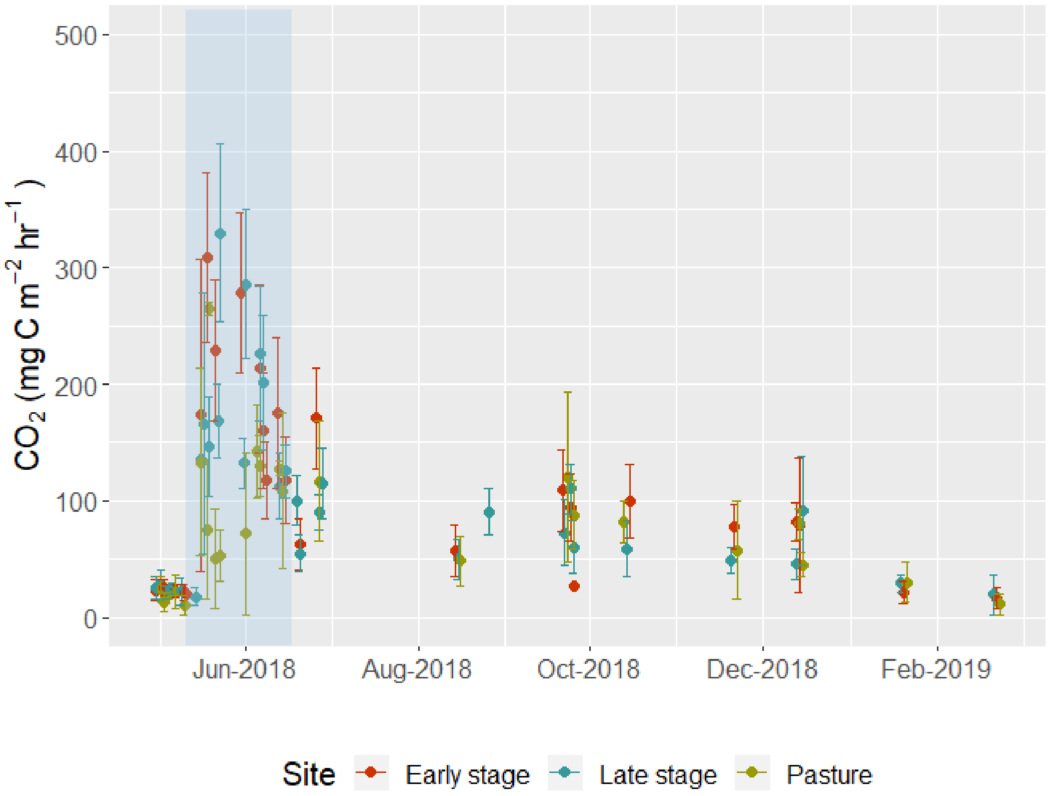
Effect of soil CO_2 emissions pulses in the Net Ecosystem Exchange

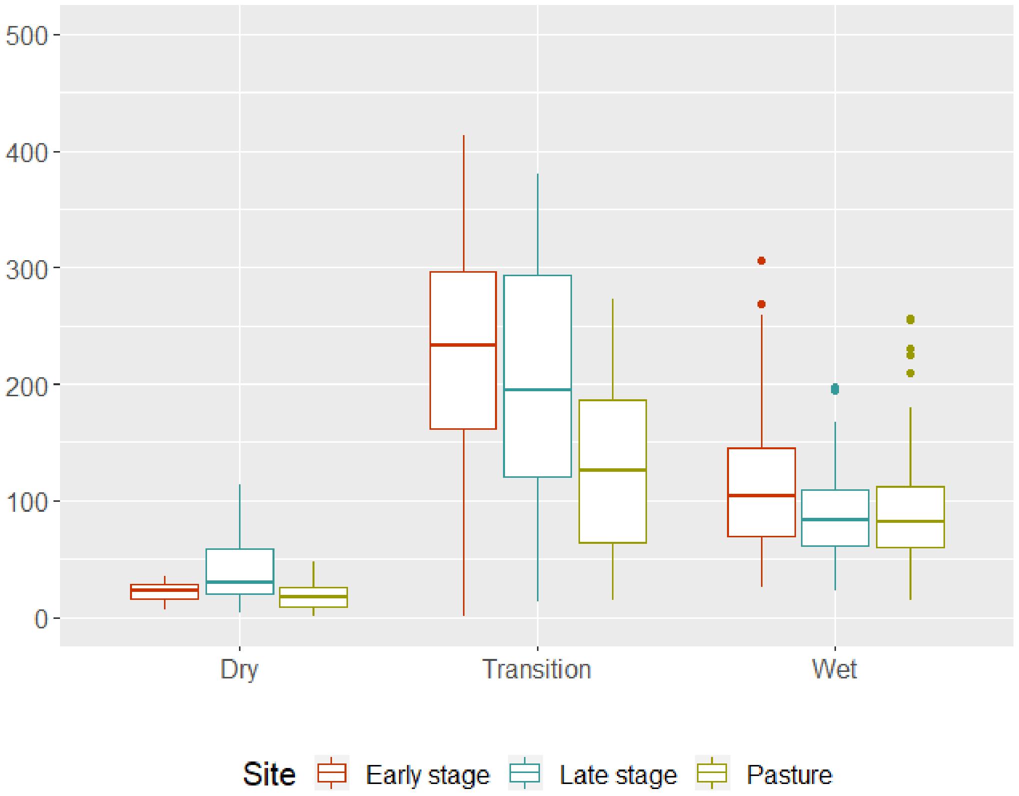
Daily average of NEE remained positive for 35 days in the transition to wet season while soil fluxes are high



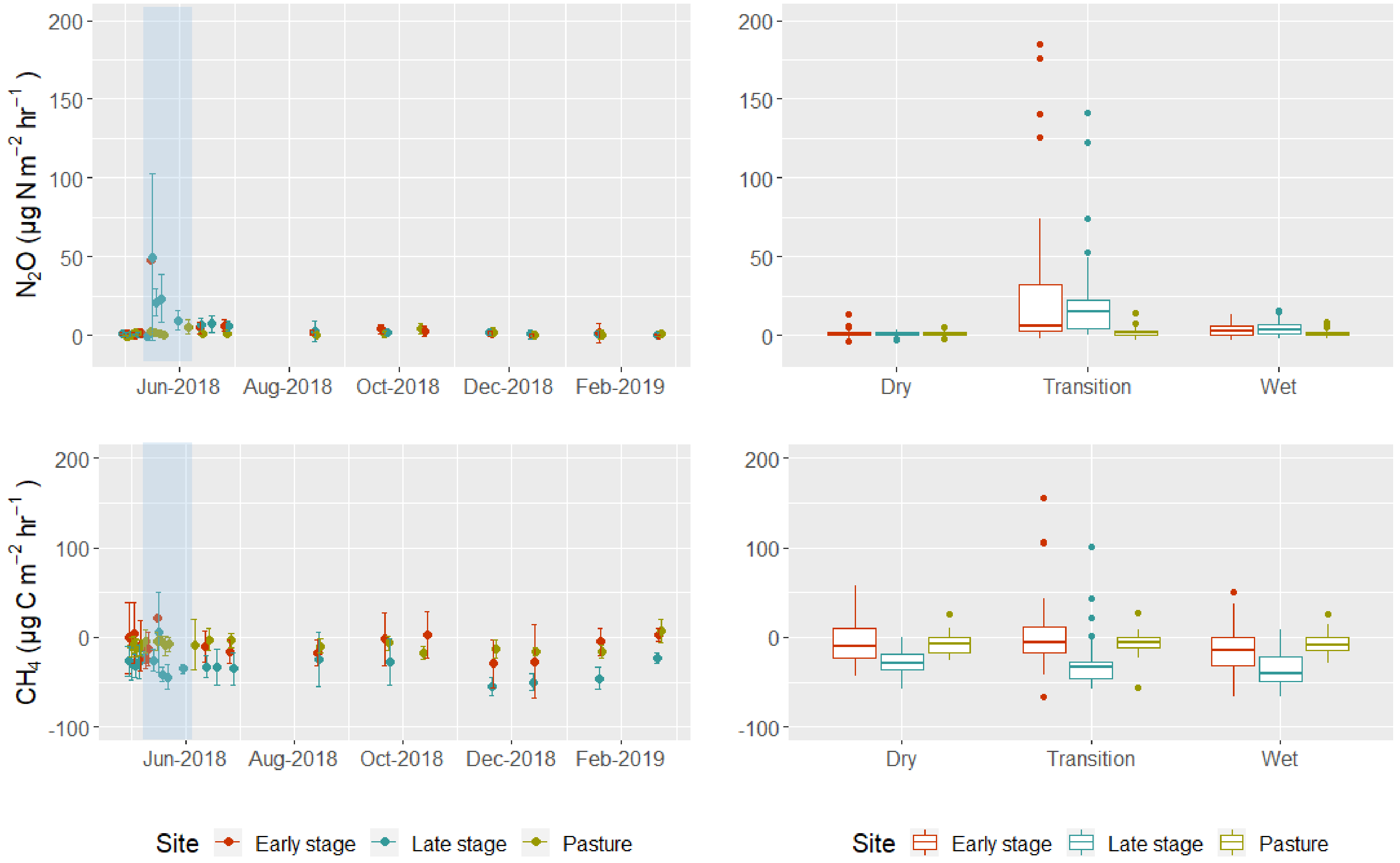
Carbon losses in the transition represent approx. 44% of the annual Carbon gain by the forest

Seasonal variations and pulses of CO_2 fluxes during dry, transition and wet seasons using the manual dark chambers

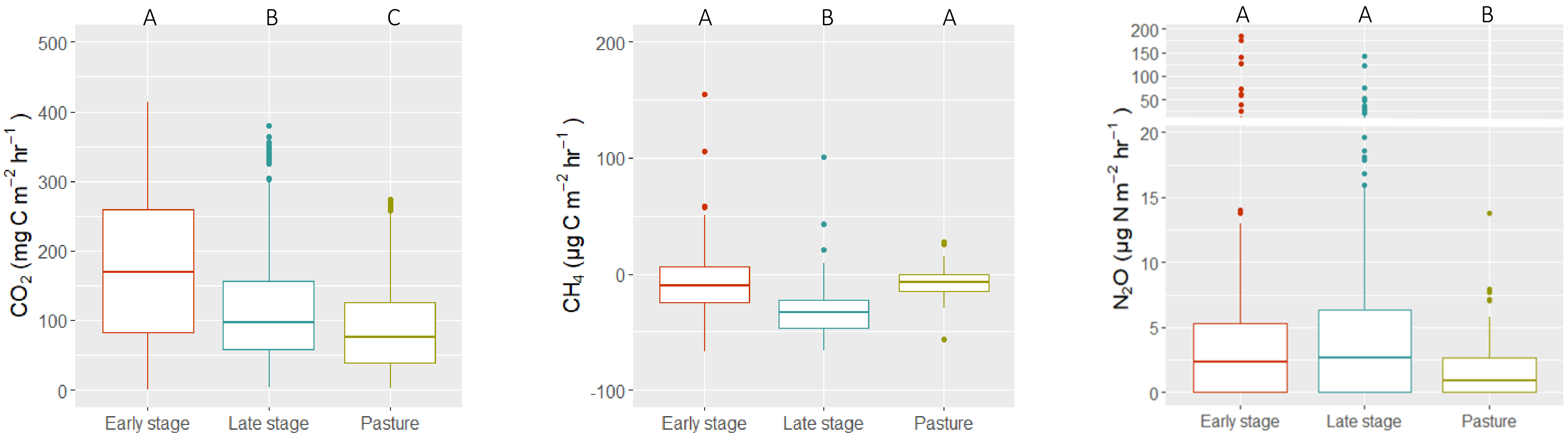




Seasonal variations and pulses N_2O and CH_4 fluxes during dry, transition and wet seasons using the manual dark chambers

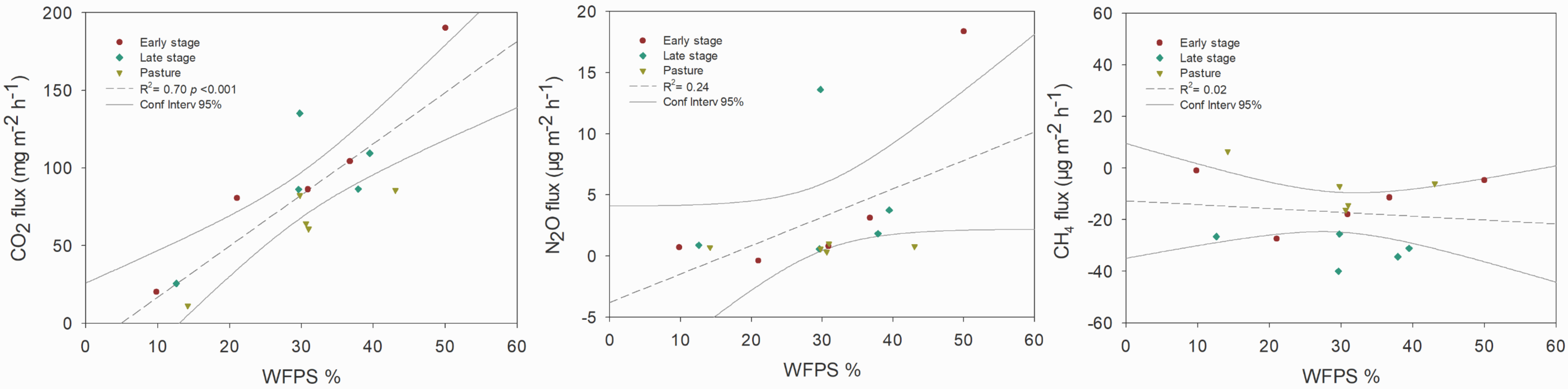


Annual differences in emissions between land covers



Capital letters indicate significant differences between the land covers ($p < 0.05$)

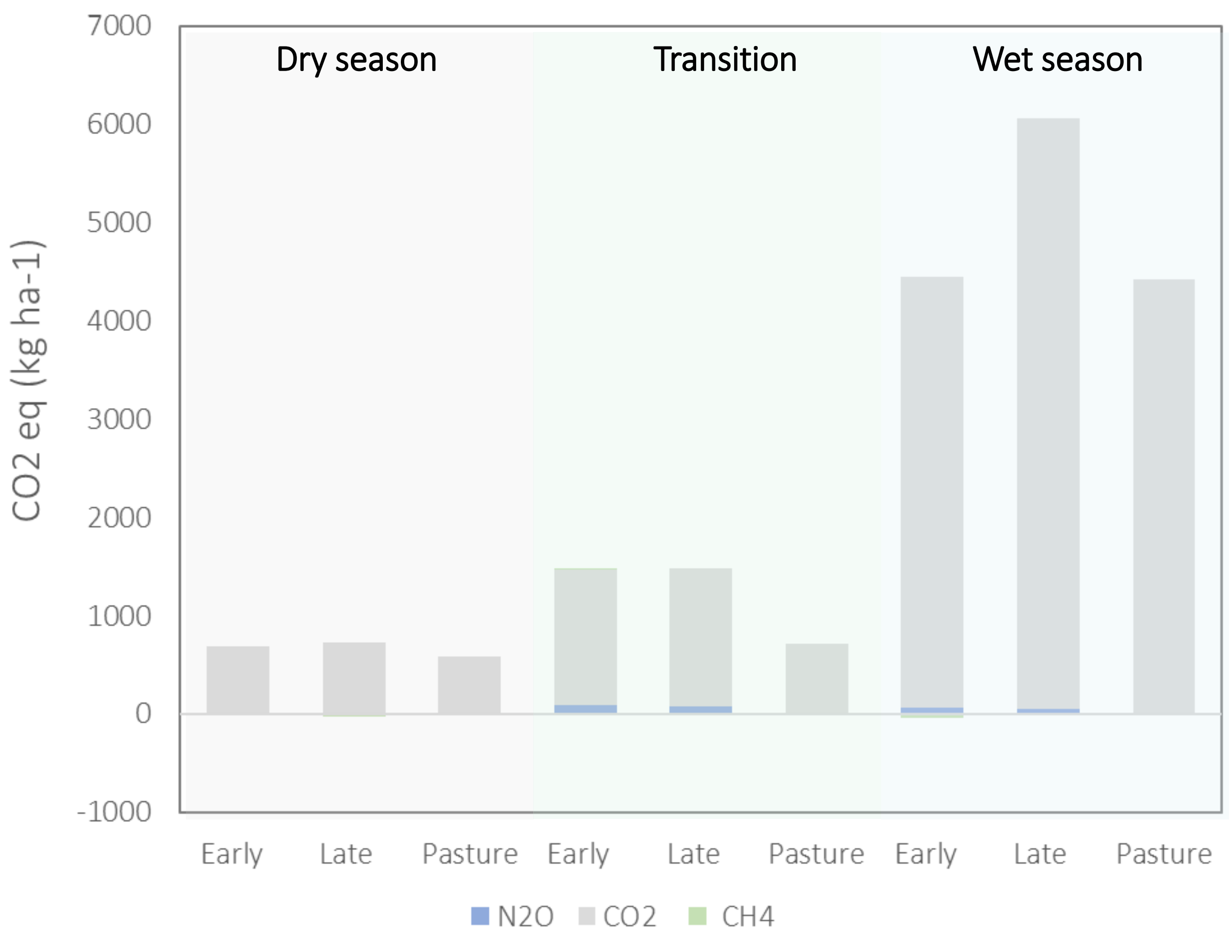
Relationship between the different GHG and WFPS



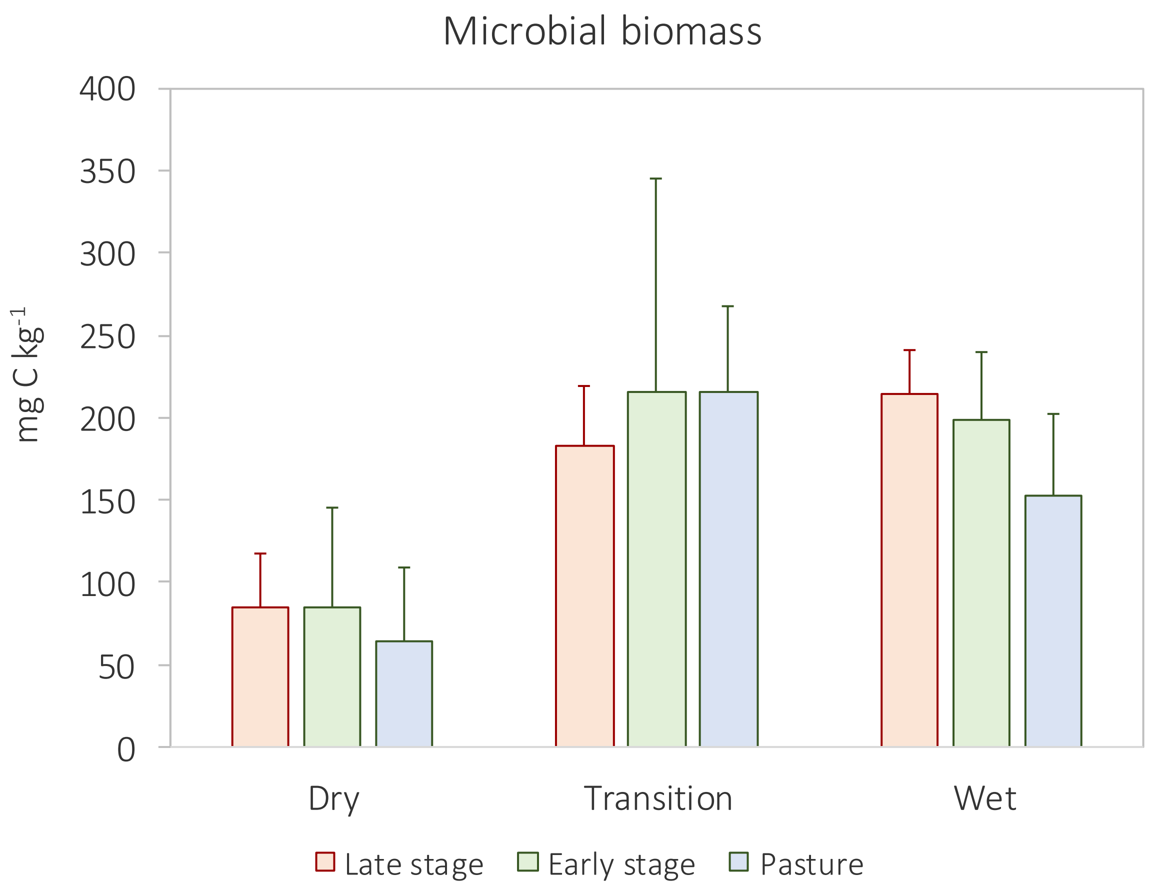
Seasonal and annual sink/source strength of GHG

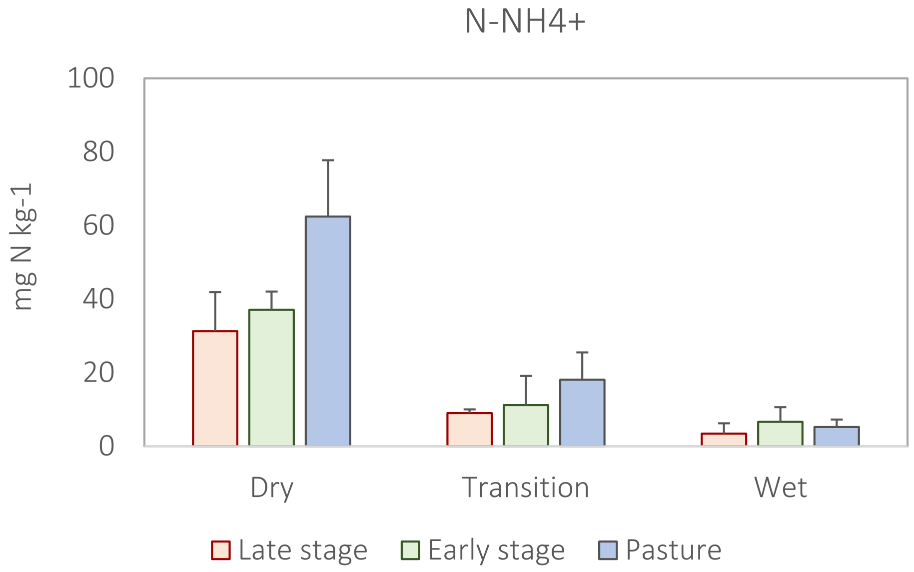
- N_2O contributes on average 4% of total soil GHG emissions in the transition season, 1% in the wet season and 2% annually

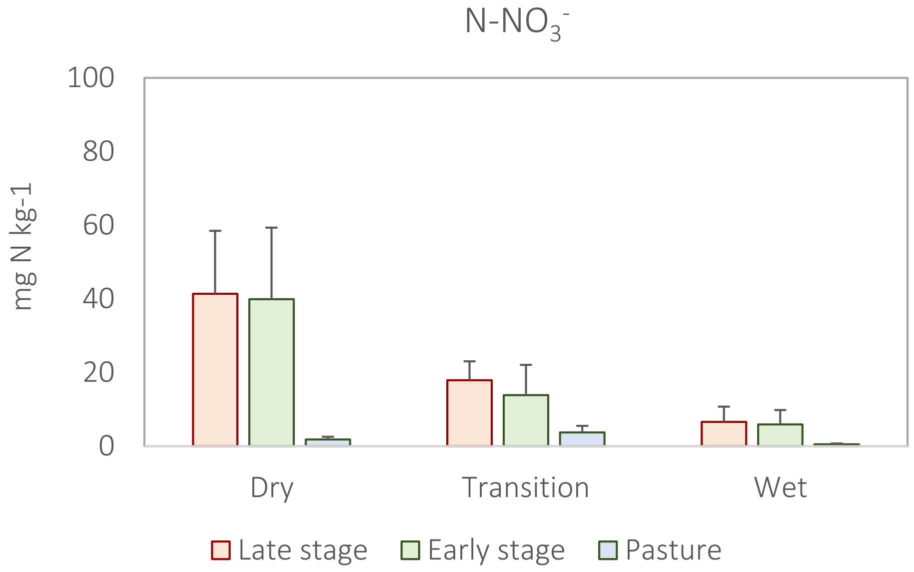
- CH_4 uptake represents on average 1% of total soil GHG emissions annually



Seasonal variations of microbial biomass, ammonium and nitrate at each stage







Using stepwise multiple regression best models were selected to identify environmental factors controlling GHG exchanges

CO_2 ~ WFPS R^2=0.70 $p <0.001$

N_2O ~ WFPS - MB R^2=0.24 $p <0.1$

CH_4 ~ -WFPS + NH_4 R^2=0.35 $p <0.05$

5. Take home messages

→ Our data suggest that TDF can be important sources N_2O and CO_2 at the start of the wet season and need to be better accounted for GHG emissions inventories in Tropical Dry Forest

→ Moreover, our data also stress the need for more spatially and temporal extensive sampling of soil variables and fluxes across different land covers in TDF in order to predict ecosystem-scale responses to climate change

Sofia Calvo-Rodriguez

Earth and Atmospheric Sciences Department

University of Alberta

calvorod@ualberta.ca

Acknowledgements

MICMOR

KIT
Karlsruhe Institute of Technology
Institute for Meteorology and
Climate Research
IMK-IFU

UNIVERSITY OF ALBERTA
QUAECUMQUE VERA

The Rufford Foundation

TROPI-DRY

References

Birch, H. F. (1958). The effect of soil drying on humus decomposition and nitrogen. *Plant Soil,* 10, 9–31

Castro, S. M., Sanchez-Azofeifa, G. A., & Sato, H. (2018). Effect of drought on productivity in a Costa Rican tropical dry forest. *Environmental Research Letters*, *13*(4), 045001.

Portillo-Quintero, C. A., & Sánchez-Azofeifa, G. A. (2010). Extent and conservation of tropical dry forests in the Americas. *Biological conservation*, *143*(1), 144-155.

Waring, B. G., & Powers, J. S. (2016). Unraveling the mechanisms underlying pulse dynamics of soil respiration in tropical dry forests. *Environmental Research Letters*, *11*(10), 105005.